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:TION MANUAL

406

MODEL 181
XCG/SWEEP GENERATOR

WAVETEK

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INSTRUCTION MANUAL

MODEL 181
XCG / SWEEP
GENERATOR

WAVETEK
Box 651, San Diego, Calif., 714-279-2200

6/75

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SECTION 1
GENERAL DESCRIPTION

1.1 THE MODEL 181

The Wavetek Model 181 XCG/Sweep Generator is a precision source of sine, triangle, and square waveforms. Frequency of the waveforms is manually and remotely variable from 0.1 Hz to 2 MHz. Select frequencies from 1 Hz to 2 MHz can be locked to an internal crystal oscillator for maximum frequency accuracy. The generator can repetitively sweep from one frequency to a higher frequency, with controllable rate and range of sweep. Amplitude of the waveforms is variable from 10V peak-to-peak into 50Ω down to 30 mV p-p. DC reference of the waveforms can be offset positively and negatively.

A voltage representing generator frequency, a fixed amplitude pulse train of that frequency, and a voltage ramp representing frequency sweep rate are provided as front panel outputs.

1.2 SPECIFICATIONS

The specifications (available waveforms, frequencies, and amplitudes), operating modes, precision (accuracy), and purity (quality) are listed in the following paragraphs.

1.2.1 Versatility

Output Signals
Sine ∿ , triangle △ , square ⊓ , TTL pulse ⎍ , ramp ◿ and DC.

Control
Generator operates in continuous and sweep modes. Frequency controlled manually or with external voltage.

Frequency Range
0.1 Hz to 2 MHz in seven overlapping ranges.

Operating Frequency Ranges

X 1	0.1 Hz to 2 Hz
X 10	0.1 Hz to 20 Hz
X 100	0.2 Hz to 200 Hz
X 1K	2 Hz to 2 kHz
X 10K	20 Hz to 20 kHz
X 100K	200 Hz to 200 kHz
X 1M	2 kHz to 2 MHz

NOTE

XCG frequencies in all ranges except X 1.

Main Output
Sine, triangle and square waveforms and DC are selectable. HI (0 dB) and LO (−20 dB) BNC outputs are available for simultaneous usage; outputs may be varied to HI (−30 dB) and LO (−50 dB) by amplitude control. HI output provides 20V peak-to-peak max open circuit (10V peak-to-peak max into 50Ω load). LO output provides 1V peak-to-peak max into 50Ω load. Both output impedances are 50Ω.

DC Offset and DC Output
DC offset of waveform and DC output selectable and variable through HI and LO BNC outputs. HI output ±10V max (±5V into 50Ω load) as offset or Vdc output. LO output ±1V max into 50Ω load as offset or Vdc output. Waveform offset limited to ± 10 Vp HI and ± 1 Vp LO (both open circuit voltages).

Pulse Output
TTL pulse (50% duty cycle) at generator frequency. Drives up to 20 TTL loads.

GCV Output
0 to +2V (nominal, open circuit) proportional to frequency of main generator. Output impedance 600Ω.

VCG — Voltage Controlled Generator Input
VCG voltage as well as control settings select generator frequency. Frequency may be dc-programmed or ac-modulated by external 0 to 2V signal. Input impedance is 2 kΩ. VCG input can change generator output 1000:1 on all ranges except X 10 Hz and X 1 Hz ranges.
VCG Input Signal Bandwidth: 100 kHz.
VCG Slew Rate: 0.1V/μs.

Sweep Output
Ramp waveform output with 5V peak into open circuit. Output impedance 600Ω.

1.2.2 Operating Modes

Continuous
XCG Off: Operates as standard VCG. Frequency of main generator determined by dial/range setting and VCG input voltage.

XCG On: Operates as a standard VCG except output of main generator determined by dial and VCG input voltage is in 20 harmonic-related frequencies with crystal accuracy on all ranges except X 1. Crystal lock indicated by lighted XCG lamp. Lock occurs at every major mark on dial (from 0.1 to 2.0 in 0.1 increments and for the equivalent VCG voltages plus dial.

Sweep

XCG Off: Main generator is frequency modulated by internal sweep generator. When swept, main generator frequency rises from frequency set by the dial and range setting to a frequency set by sweep width control.

Sweep Rate: 30 ms to 20s (nominal) continuously adjustable by single turn control on front panel.

Sweep Width: Up to 1:1000 adjustable on all ranges except X 1 Hz and X 10 Hz ranges.

XCG On: This mode is not recommended. However, discrete frequency stepping with indeterminate frequencies between steps does occur for XCG frequencies within the sweep range, provided the sweep time between each frequency does not exceed the locking time of the XCG circuit.

1.2.3 Horizontal Precision

Dial Accuracy

XCG Off: ±3% of full scale, 0.1 Hz to 2 MHz.

XCG On: ±0.01% of XCG setting (when XCG lamp is on). (X 10 range accuracy must be measured over a 10s period.)

Time Symmetry

XCG Off: ±1% on all but X 1M range.

XCG Lock Time

X 1K thru X 1M . . . . . Less than 500 ms

X 100 . . . . . Less than 5s

X 10 . . . . . Less than 50s

1.2.4 Vertical Precision

Amplitude Change With Frequency (Sine)

Less than ±0.1 dB on all ranges thru X 100K.

Less than ±0.5 dB on X 1M range.

1.2.5 Waveform Purity

Sine Distortion

Less than 0.5% on X 100, X 1K, X 10K ranges (typically 0.2%).

Less than 1.0% on X 1, X 10, X 100K ranges (typically 0.5%).

All harmonics 30 dB down on X 1M range.

Square Wave Rise and Fall Time

Less than 75 nanoseconds.

Triangle Linearity

Greater than 99%, to 200 kHz.

1.2.6 Environmental

Specifications apply at 25°C ±5°C. Instrument will operate from 0°C to +50°C.

1.2.7 Mechanical

Dimensions

11¼ in./28.6 cm wide; 4 in./10.2 cm high; 10½ in./26.7 cm deep.

Weight

6.5 lb/2.9 kg net; 9.5 lb/4.3 kg shipping.

1.2.8 Power

105V to 125V or 200V to 250V, 50 Hz to 400 Hz. Less than 18 watts.

NOTE

All specifications apply when: frequency dial is between 0.1 and 2.0, amplitude is at 10V p-p and output is from HI BNC into 50Ω load.

SECTION 2
INITIAL PREPARATION

2.1 UNPACKING INSPECTION

After carefully unpacking the instrument, inspect the external parts for damage to knobs, dials, indicators, surface areas, etc. If there is damage, file a claim with the carrier who transported the instrument. Retain the shipping container and packing material for use in case reshipment is required.

2.2 PREPARATION FOR USE

Before connecting the instrument to line power, check that the rear panel 115/230V switch is set to the value nearest the line voltage and that the fuse is correct for the switch setting. Check that the plug on the power cord is the mate for the line receptacle.

2.3 ELECTRICAL ACCEPTANCE CHECK

This checkout procedure verifies the generator operation. If a malfunction is found, refer to the Warranty in the front of this manual. An oscilloscope, frequency counter, 50Ω coax cables and 50Ω feedthru are needed for this procedure (see figure 2-1). Preset the genreator front panel controls as follows:

Control	Position
FREQ MULT	PWR OFF
Frequency Dial	1.0
Function	∿
AMPLITUDE	Full clockwise
DC OFFSET	OFF
SWEEP WIDTH	OFF
SWEEP RATE	9 o'clock
XCG Switch	XCG

Perform the steps in table 2-1. Where tolerances are not given, only approximate values are required to verify operation.

2.4 CHANGING THE OUTPUT IMPEDANCE

The output impedance is normally:

HI 50Ω @ 10V p-p
LO 50Ω @ 1V p-p

Attenuation is normally 0 - 30 dB. Lowest possible amplitude is −50 dB.

If simultaneous 600Ω and 50Ω output impedances are desired:

1. Change value of R145 from 499Ω to 604Ω.

2. Remove R147.

The result is:

HI 50Ω @ 10V p-p
LO 600Ω @ 10V p-p (low power)

Attenuation is 0 - 30 dB. Lowest possible amplitude is −30 dB. Square wave rise and fall is <150 ns.

If 50Ω and any other impedance greater than 600Ω are desired, replace R145 with resistor of that value.

If 50 dB of attenuation control is desired in a modified instrument, change R121 from 33.2Ω to 1.8Ω. Waveform quality above 20 kHz will be considerably impaired at −50 dB compared to a standard instrument.

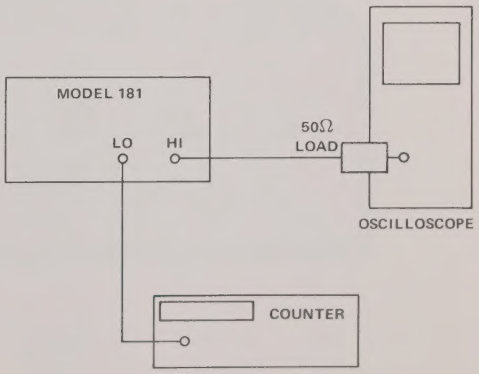

Figure 2-1. Acceptance Test Setup

Table 2-1. Performance Checkout

Step	Control	Position/Operation	Observe at 50Ω OUT
1	FREQ MULT	X 10	10 ±0.001 Hz; 10V p-p sine wave on oscilloscope. Allow 50s settling time.
2	FREQ MULT	X 100, - - - X 1M	Frequency increases by a decade for every change of switch position. Respective tolerances are: ±0.01 Hz, ±0.1 Hz, ±1 Hz, ±10 Hz, and ±100 Hz.
3	XCG Switch	OFF	1 MHz.
4	FREQ MULT	X 1	1 Hz.
5	FREQ MULT	X 1K	– – –
6	Function	∿	Triangle wave.
7	Function	⊓	Square wave.
8	AMPLITUDE	ccw	Decrease in waveform amplitude.
9	DC OFFSET	cw	Positive slew of waveform from full negative offset.
10	DC OFFSET	ccw	Negative slew of waveform.
11	DC OFFSET	OFF	– – –
12	AMPLITUDE	Full cw	– – –
13	Dial	Full cw	– – –
14	SWEEP WIDTH	Full cw	Frequency of waveform repetitively sweeps.

SECTION 3
OPERATION

3.1 CONTROLS AND CONNECTORS

The generator front panel controls and connections shown in figure 3-1 are keyed by circled numbers to the following descriptions.

3.1.1 Power/Frequency Controls

① **FREQ MULT/PWR OFF**

Power is turned on when frequency range is selected at the FREQ MULT (Hz) control. The ranges multiplied by frequency dial ② settings determine output frequency. The frequency dial index lights when power is turned on.

② **Frequency Dial**

Frequency dial settings multiplied by frequency range ① determine output frequency.

③ **XCG Switch**

When the XCG switch is on, the frequencies associated with each major dial mark ② are locked to a crystal oscillator. Lock is indicated by the XCG lamp ④ on.

④ **XCG Lamp**

When the generator output frequency is locked to the crystal oscillator, the XCG lamp lights.

⑤ **VCG IN Connector**

Voltage controlled generator input (VCG IN) dc excursions proportionally control frequency within a selected range. Positive inputs increase frequencies set by the frequency dial and range control; negative inputs decrease the frequencies.

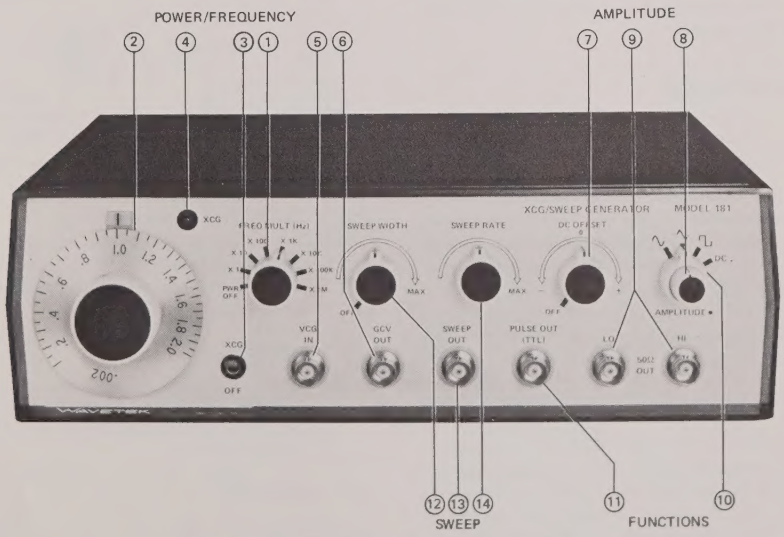

Figure 3-1. Model 181 Controls and Connectors

⑥ **GCV OUT Connector**

Generator controlled voltage output (GCV OUT) dc excursions of 0V to about 2V proportionally represent output frequency within a given range.

3.1.2 Amplitude Controls

⑦ **DC OFFSET**

Rotating the DC OFFSET control clockwise offsets dc center reference of waveform positive; when counterclockwise, negative. When OFF, the waveform is balanced around signal ground (figure 3-2).

⑧ **AMPLITUDE**

Rotating the AMPLITUDE control fully clockwise provides maximum peak-to-peak output at the 50Ω OUT connectors; counterclockwise for up to 30 dB attenuation of output amplitude.

⑨ **50Ω OUT Connectors**

Maximum output of 10V p-p signals into a 50Ω load (20V p-p open circuit) is provided at the 50Ω OUT HI connector, and 20 dB below (1/10 or a 1V p-p maximum) of that level at the 50Ω OUT LO connector.

3.1.3 Function Selections

⑩ ∿ , ∿ , ⊓ **and DC (Waveforms)**

Sine ∿ , triangle ∿ , and square ⊓ waveforms are selected by the larger of the two concentric controls; the DC position provides a dc voltage output of the waveform center reference level at the 50Ω OUT ⑨ connectors.

⑪ **TTL PULSE OUT Connector**

A fixed amplitude Transistor-Transistor Logic (TTL) square pulse train of the output frequency is provided at the PULSE OUT (TTL) connector. (TTL levels are 0V to 0.4V for a logic low and 2.4V to 5V for a logic high.) The output can drive up to 20 TTL loads. The pulse train can also be used as a synchronizing reference for the main output ⑨ . Phase of the waveforms relative to the TTL pulse is shown in figure 3-2.

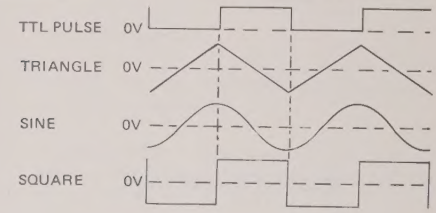

Figure 3-2. Output Waveforms

3.1.4 Sweep Controls

⑫ **SWEEP WIDTH/OFF**

Main output (at 50Ω OUT HI or LO) frequency sweep is turned on when SWEEP WIDTH is rotated past OFF. Rotation of the control varies the peak amplitude of an internal ramp signal (seen at GCV OUT) whose voltage controls the frequency of the main generator (seen at 50Ω OUT). See figure 3-3.

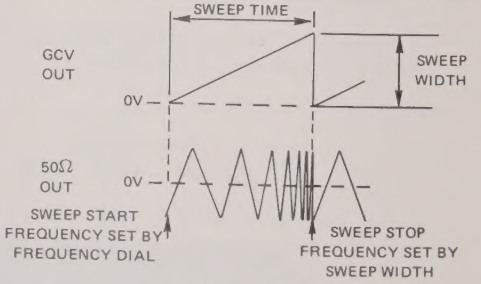

Figure 3-3. Effect of Sweep on Output Frequency

⑬ **SWEEP OUT Connector**

The sweep generator ramp is available at the SWEEP OUT connector. Amplitude is 0V to 5V peak (600Ω source impedance).

⑭ **SWEEP RATE**

Rotation of SWEEP RATE controls duration of the sweep voltage ramp, and thus frequency of sweep repetition.

3.2 OPERATION

Operation can be quite varied but is described here as manual, crystal controlled, voltage controlled or sweep controlled. The generator is ready to operate as soon as a

frequency multiplier is selected; however, when output is critical, allow ½ hour warm up.

3.2.1 Signal Termination

Proper signal termination, or loading, of the generator connectors is necessary for its specified operation. For example, the proper termination of the main output is shown in figure 3-4. Placing the 50 ohm terminator, or 50 ohm resistance, in parallel with a higher impedance, matches the receiving instrument input impedance to the generator output impedance, thereby minimizing signal reflection or power loss on the line due to impedance mismatch.

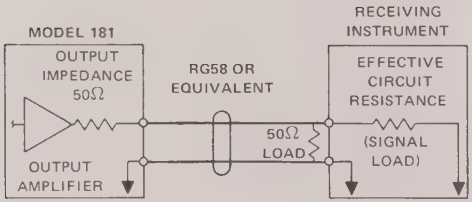

Figure 3-4. Signal Termination

The input and output impedance of the generator connectors are listed below:

Connector	Impedance
50Ω OUT HI	50Ω
50Ω OUT LO	50Ω
PULSE OUT (TTL)	*
SWEEP OUT	600Ω
VCG IN	2 kΩ
GCV OUT	600Ω

*The PULSE OUT connector can drive up to 20 Transistor-Transistor Logic (TTL) loads (low level between 0V and 0.4V, and high level between 2.4V and 5V).

3.2.2 Manually Controlled Operation

For basic operation, select the waveform to be output, and set the output signal frequency and amplitude. The following steps demonstrate manual control of the function generator:

Step	Control/Connector	Setting
1	50Ω OUT	Connect circuit to either HI or LO output (Ref: paragraph 3.2.1).
2	FREQ MULT	Set to desired range of frequency.
3	Frequency Dial	Set to desired frequency.
4	Waveform Selector	Set to desired waveform.
5	DC OFFSET	See figure 3-5.
6	AMPLITUDE	Select desired amplitude.

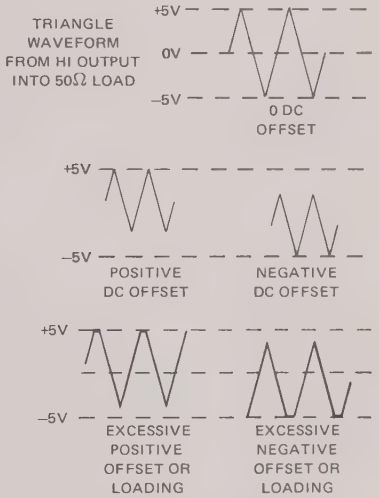

Figure 3-5. DC OFFSET Control

3.2.3 Crystal Controlled Operation

Crystal control allows selected XCG frequencies to be locked to a crystal oscillator for greater accuracy. XCG frequencies correspond to each of the 20 major dial marks in every range except X 1. The following steps demonstrate crystal controlled operation:

Step	Control/Connector	Setting
1	50Ω OUT	Connect circuit to either HI or LO output (refer to paragraph 3.2.1).
2	XCG Switch	XCG

Step	Control/Connector	Setting
3	FREQ MULT	Set to desired range of frequency.
4	Frequency Dial	Set to desired XCG frequency. (XCG lamp lights.)
5	Waveform Selector	Set to desired waveform.
6	DC OFFSET	See figure 3-5.
7	AMPLITUDE	Select desired amplitude.

3.2.4 Voltage Controlled Operation

Operation as a voltage controlled function generator (VCG) is as for a manually controlled function generator, only the frequency within particular ranges is additionally controlled with dc levels (±2V excursions) injected at the VCG IN connector. Perform the steps given in paragraph 3.2.2, only set the frequency dial to determine a reference from which the frequency is to be voltage controlled:

1. For frequency control with positive dc inputs at VCG IN, set the dial for a lower frequency limit.

2. For frequency control with negative dc inputs at VCG IN, set the dial for an upper frequency limit.

3. For modulation with an ac input at VCG IN, set the dial at the desired center frequency. Do not exceed the maximum dynamic range of the selected frequency range.

NOTE

Crystal control and voltage control may be used simultaneously. However, ac excursions in this mode are not recommended.

Figure 3-6 is a nomograph with examples of the frequency dial effect as a reference for VCG IN voltages. Example 1 shows that with 0V VCG input, frequency is as determined by the main dial setting, 1.0 in this example. Example 2 shows that with a positive VCG input, output frequency is increased. Example 3 shows that with a negative VCG input, output frequency is decreased. (Note that the 50Ω OUT Frequency Factor column value must be multiplied by a frequency range multiplier to give the actual 50Ω OUT frequency.)

NOTE

Nonlinear operation results when the VCG input voltage is excessive; that is, when the attempted generator frequency exceeds the range setting (2 times the multiplier setting), or in the other direction, 1/1000 of the range setting.

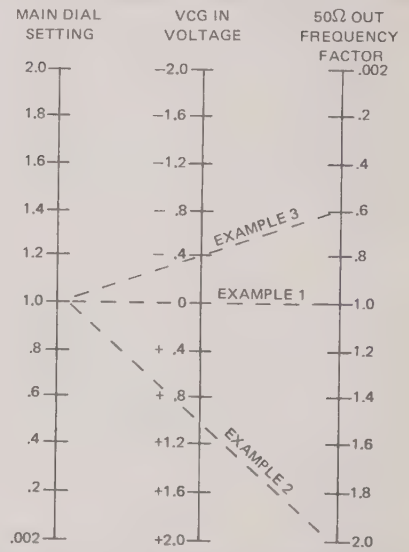

Figure 3-6. VCG Voltage-to-Frequency Nomograph

The up to 1000:1 VCG sweep of the generator frequencies available in each range results from a 2V excursion at the VCG IN connector. With the frequency dial set to 2.0, excursions between −2V and 0V at VCG IN provide the up to 1000:1 frequency sweep. With the dial set to .002, excursions between 0V and +2V at VCG IN provide the up to 1000:1 sweep within the set frequency range.

3.2.5 Sweep Generator Operation

Operation as a sweep generator is like operation as a manual function generator, only the frequency is automatically and repetitively swept from the set frequency to a higher frequency. Actually, an internally generated positive-going voltage ramp (available at the SWEEP OUT connector) can be modified in amplitude and used like a VCG input voltage to sweep the output frequency (see figure 3-3). Perform the steps in paragraph 3.2.1 and the following steps for use as a sweep generator:

Step	Control/Connector	Setting
1	SWEEP WIDTH	As desired. This determines the upper frequency of the sweep.

Step	Control/Connector	Setting
2	SWEEP RATE	As desired. This determines the speed of the sweep.

NOTE

To monitor the ramp generator, use the SWEEP OUT connector. To monitor the frequency of the main generator, use the GCV OUT connector, which is a voltage proportional to the generator frequency.

Crystal control and sweep control may be used simultaneously, but it is not recommended. However, discrete frequency stepping does occur for XCG frequencies within the sweep range provided the sweep time between each frequency does not exceed the lock time of the XCG circuit.

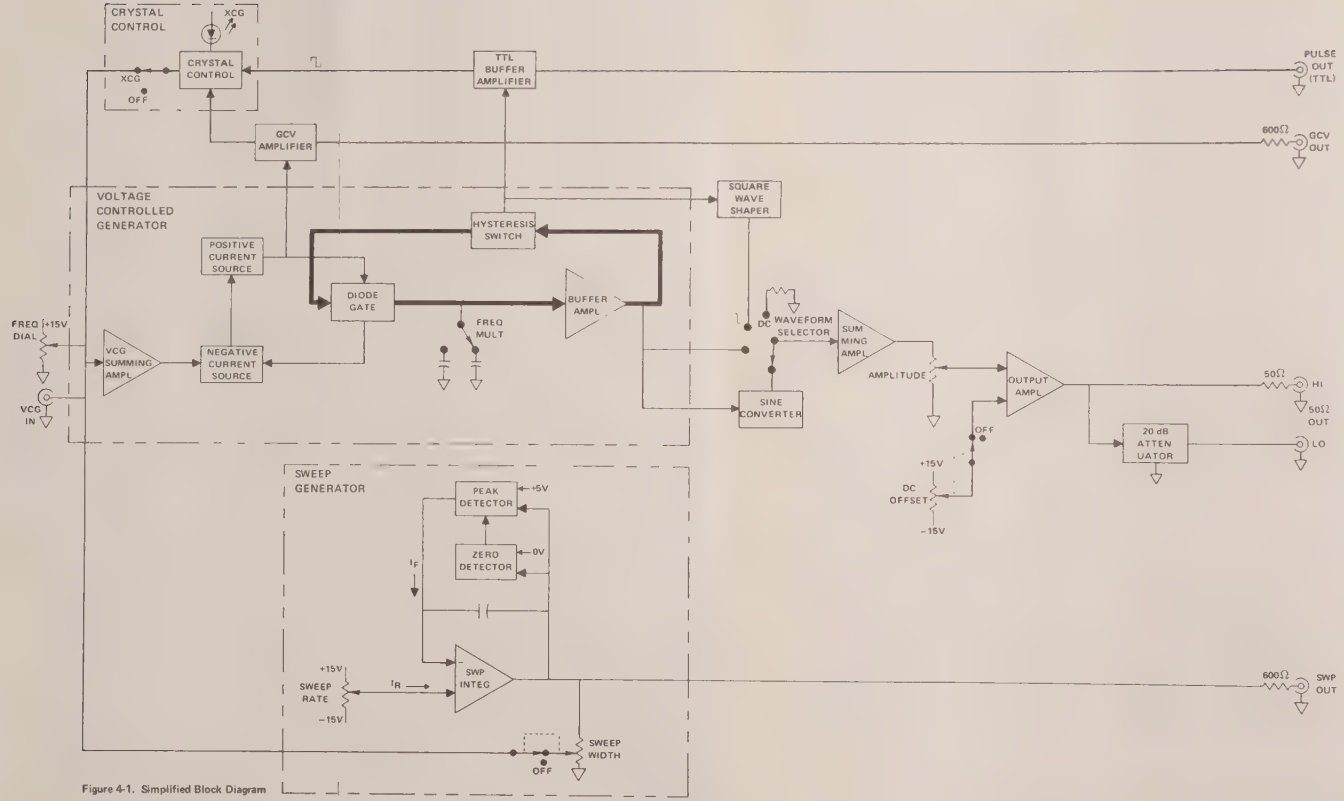

Figure 4-1. Simplified Block Diagram

SECTION 4
CIRCUIT DESCRIPTION

4.1 VOLTAGE CONTROLLED GENERATOR (VCG)

As shown in figure 4-1, the VCG summing amplifier sums the currents from the frequency dial, sweep generator, crystal control and VCG input connector. The VCG summing amplifier is an inverting amplifier whose output current is used to control a positive current source and a negative current source. The currents from the two current sources are equal and opposite polarity and the magnitudes are directly proportional to the current of the VCG summing amplifier output. The diode gate, which is controlled by the hysteresis switch, is used to switch the positive current or the negative current to the integrating capacitor selected by the frequency multiplier. If the positive current is switched into the capacitor, the voltage across the capacitor will increase linearly to generate the positive slope of the triangle wave. If the current is negative, the voltage across the capacitor will decrease linearly to produce the negative slope.

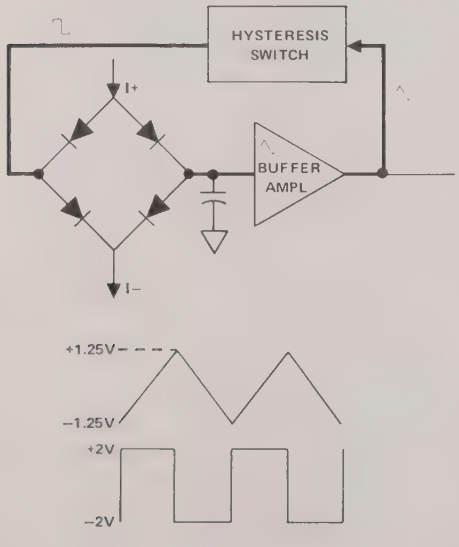

Figure 4-2. Simplified Timing Diagram

The triangle buffer amplifier is a unity gain amplifier whose output is fed to the hysteresis switch as well as to the sine converter. The hysteresis switch has two voltage limit points (+1.25V and −1.25V). (See figure 4-2.)

During the time the output voltage of the triangle buffer amplifier is increasing, the output voltage of the hysteresis switch is positive, but when the output voltage of the triangle amplifier reaches +1.25V, it triggers the hysteresis switch causing the switch output to become negative. Once the control voltage into the diode gate becomes negative, it will switch the positive current out and switch the negative current in to the integrating capacitor, starting a linear decrease of the voltage across the capacitor. When the decreasing voltage reaches −1.25V, the output of the hysteresis switch will switch back to positive, reversing the process. This action generates the triangle waveform as shown in figure 4-2. Since the output of the hysteresis switch is a square wave, the result is simultaneous generation of a square wave and triangle wave at the same frequency.

4.2 FREQUENCY CONTROL

The output frequency is determined by the magnitude of the integrating capacitor selected by the frequency multiplier and the magnitude of the positive and negative current sources (figure 4-1). Since the current magnitudes are linearly proportional to the sum of the VCG current, the output frequency will also be linearly proportional to the current sum.

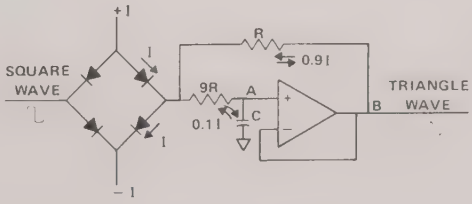

Figure 4-3. Current Divider

By using current division, the magnitude of the capacitor is effectively increased, allowing the generation of lower frequencies. Figure 4-3 is the simplified diagram showing current divider operation. By reducing integration current precisely by a factor of 10 while holding triangle wave amplitude constant, it is possible to extend the lower frequency range by a factor of 10 with fixed capacitance C. Since points A and B are at the equipotential points, constant current output I can be divided by resistance ratio of R and 9R. Then, integration current of capacitor C is reduced to 0.1 I. The lower current extends the frequency range of the function generator by a factor of 10. The same theory is applied to extend the frequency range by a factor of 100.

4.3 WAVEFORM OUTPUT

The inverted output of the hysteresis switch is fed to the TTL buffer amplifier and also the square wave shaper (figure 4-1). The square wave shaper consists of a shaping circuit which limits the output swing to ±1.25 volts.

The output signal from the triangle buffer amplifier is applied to the sine converter, which uses a diode-resistor network with linear sections to shape a sine wave.

The sine, triangle or square waveform is fed to the summing amplifier through the waveform selector switch. The output of summing amplifier is fed through the amplitude control to the output amplifier. The output amplifier is an inverting amplifier whose output is capable of driving 10V p-p into 50Ω load from 50Ω source impedance.

4.4 SWEEP CIRCUITS

Sweep rate control determines the amount of integrating current fed to the positive input of the sweep integrator (figure 4-1). The output voltage increases linearly as the sweep circuit capacitor is charged to form the positive slope of the ramp. As the ramp output reaches the preset level of +5V, the peak detector turns on while the positive feedback circuit holds the positive output state. The large flyback current I_F is fed to the negative input of the sweep integrator while overcoming minute integrating current I_R. Thus, the ramp output decreases rapidly toward the negative voltage, forming the negative slope of the ramp. When the negative slope reaches zero volts, the zero detector turns on, the peak detector is unlatched and the flyback current source is turned off, allowing the output voltage to increase linearly.

4.5 CRYSTAL CONTROL

In the crystal control circuit (figure 4-1), the phase of the TTL buffer output is compared to a crystal controlled oscillator and a frequency error correction signal is generated. The error correction signal is an input to the VCG amplifier and causes the main generator to lock to the nearest harmonic of the basic XCG frequency of the range (all ranges except X 1). The basic XCG frequency corresponds to 0.1 on the dial. The harmonics correspond to the remaining major marks on the dial in 0.1 increments. In portions between major marks (harmonics), the capture bandwidth is exceeded and no locking occurs. The XCG lamp lights whenever frequency lock occurs.

SECTION 5
CALIBRATION

5.1 FACTORY REPAIR

Wavetek maintains a factory repair department for those customers not possessing the necessary personnel or test equipment to maintain the instrument. If an instrument is returned to the factory for calibration or repair, a detailed description of the specific problem should be attached to minimize turnaround time.

5.2 REQUIRED TEST EQUIPMENT

Voltmeter
Distortion Analyzer
Oscilloscope
Counter (6 digit)
50Ω (±0.1%) Load

5.3 REMOVING GENERATOR COVER

CAUTION

Be aware that a cover-mounted circuit board is attached to the instrument by a short wiring harness. Take care when lifting the cover off.

For circuit board access, remove the four screws in the lower cover, place the instrument on its feet and lift the top cover a few inches. Notice the attaching cable. Invert the cover and place near the instrument.

5.4 CALIBRATION

After referring to the following preliminary data, perform calibration, as necessary, per table 5-1. If performing partial calibration, check previous settings and adjustments for applicability.

1. Unless otherwise noted, all measurements made at the 50Ω OUT connector should be terminated into a 50Ω (≤1%, 1W) load.

2. Before connecting the unit to an ac source, check the ac line circuit to make sure the 115/230 volt switch is set at the correct position (see paragraph 2.2).

3. Start the calibration by setting the front panel switches as follows:

Dial	2.0
FREQ MULT	X 1K
SWEEP WIDTH	OFF
SWEEP RATE	ccw
DC OFFSET	OFF
Function	∿
AMPLITUDE	cw
XCG Switch	OFF

4. Allow the unit to warm up at least 30 minutes for final calibration.

Table 5-1. Calibration Chart

Step	Check	Tester	Cal Points	Control Setting	Adjust	Desired Results	Remarks
1	Power regulation	Voltmeter	TP2 (TP1 ground)		R9	+15 ±0.01V	
2			TP3			−15 ±0.05V	
3	Distortion	Distortion analyzer (50Ω terminated)	50Ω OUT HI		R78 R103	Minimum distortion	

Table 5-1. Calibration Chart (Continued)

Step	Check	Tester	Cal Points	Control Setting	Adjust	Desired Results	Remarks
4	VCG null	Scope (50Ω terminated)	50Ω OUT HI	FREQ MULT X 100K Function ⊓ Dial full cw Scope vert 2V/div Scope horiz .5 ms/div	R43	Minimum frequency shift	Adjust generator dial for 1 full square on scope. Alternately short and open VCG IN BNC while adjusting R43.
5	Horizontal symmetry			Scope X 10 on	R47	Maximum symmetry	Alternately switch scope triggering from positive to negative slope while adjusting R47.
6				Dial 0.1 FREQ MULT X 10 Scope sweep 0.1s/div, DC triggering	R66	Maximum symmetry	
7	Frequency accuracy	Counter (50Ω terminated)		Dial 2.0 FREQ MULT X 1 thru X 10K	R39	Best frequency accuracy over X 1 thru X 10K	
8				FREQ MULT X 1M Function	C19	Best frequency accuracy for all waveforms	
9	DC level	Voltmeter (50Ω terminated)		FREQ MULT X 1K Function DC Amplitude ccw	R125	0 ±20 mVdc	
10	XCG Accuracy	Counter (50Ω terminated)		XCG on Dial 2.0 FREQ MULT X 1M Function ⊓ ∿ ∿	XCG Bd Trim Cap	2 MHz ±200 Hz	XCG light must be on before adjustment

SECTION 6
TROUBLESHOOTING

6.1 FACTORY REPAIR

Wavetek maintains a factory repair department for those customers not possessing the necessary personnel or test equipment to maintain the instrument. If an instrument is returned to the factory for calibration or repair, a detailed description of the specific problem should be attached to minimize turnaround time.

6.2 TROUBLESHOOTING CHART

Troubleshooting charts are given in figure 6-1. The charts do not cover every possible trouble, but will be an aid in systematically isolating faulty components.

6.3 TROUBLESHOOTING INDIVIDUAL COMPONENTS

6.3.1 Transistor

1. A transistor is defective if more than one volt is measured across its base emitter junction in the forward direction.

2. A transistor when used as a switch may have a few volts reverse bias voltage.

3. If the collector and emitter voltages are the same, but the base emitter voltage is less than 500 mV forward voltage (or reversed bias), the transistor is defective.

4. A transistor is defective if its base current is larger than 10% of its emitter current (calculate currents from voltage across the base and emitter series resistors).

5. In a transistor differential pair (common emitter stages), either their base voltages are the same in normal operating condition, or the one with less forward voltage across its base emitter junction should be off (no collector current); otherwise, one of the transistors is defective.

6.3.2 Diode

1. A diode is defective if there is greater than one volt (typically 0.7 volt) forward voltage across it.

6.3.3 Operational Amplifier (e.g., UA741C, LM318)

1. The "+" and "−" inputs of an operational amplifier will have less than 15 mV voltage difference when operating under normal conditions.

2. If the output voltage stays at maximum positive, its "+" input voltage should be more positive than its "−" input voltage, or vice versa; otherwise, the operational amplifier is defective.

6.3.4 Capacitor

1. Shorted capacitors have zero volts across their terminals.

2. Opened capacitor can be located (but not always) by using a good capacitor connected in parallel with the capacitor under test and observing the resulting effect.

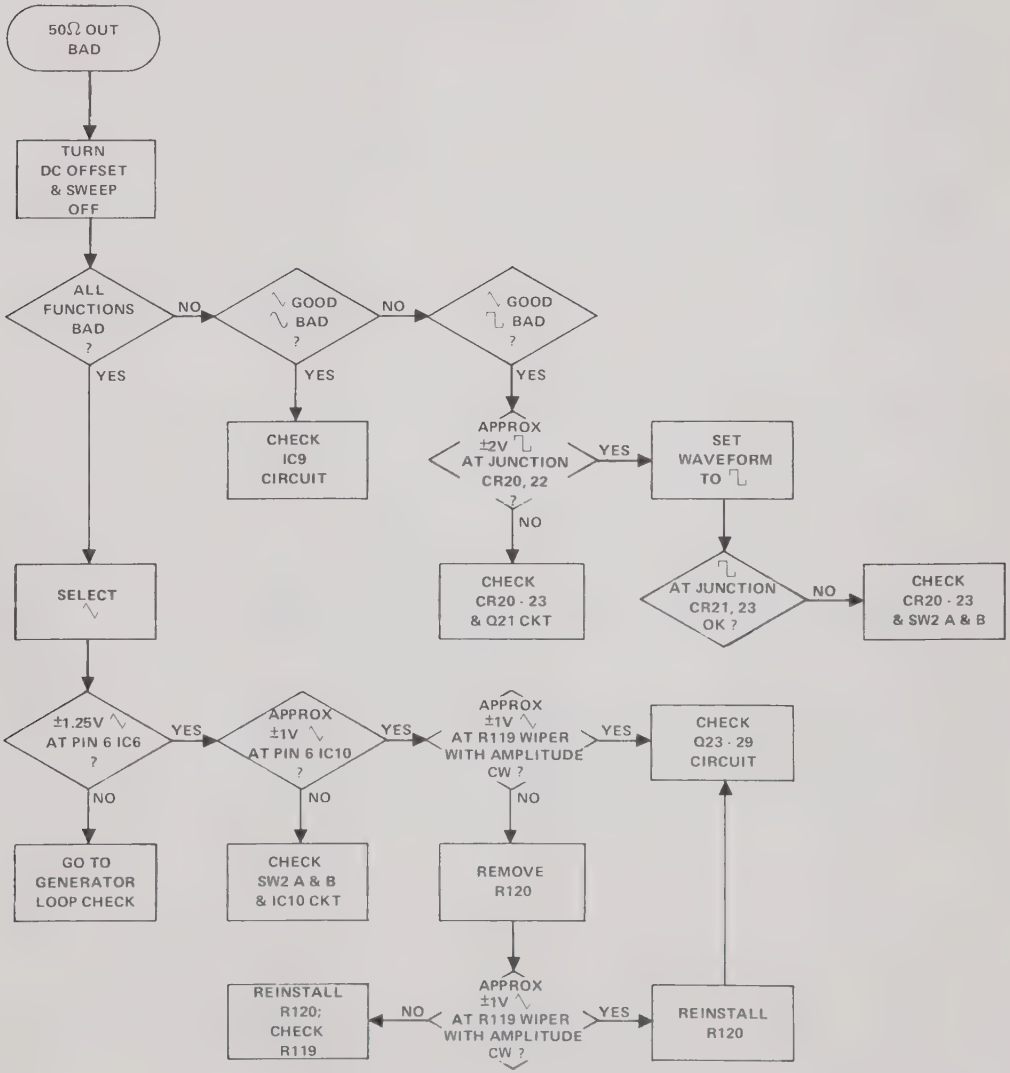

Figure 6-1. Troubleshooting Chart (Sheet 1 of 4)

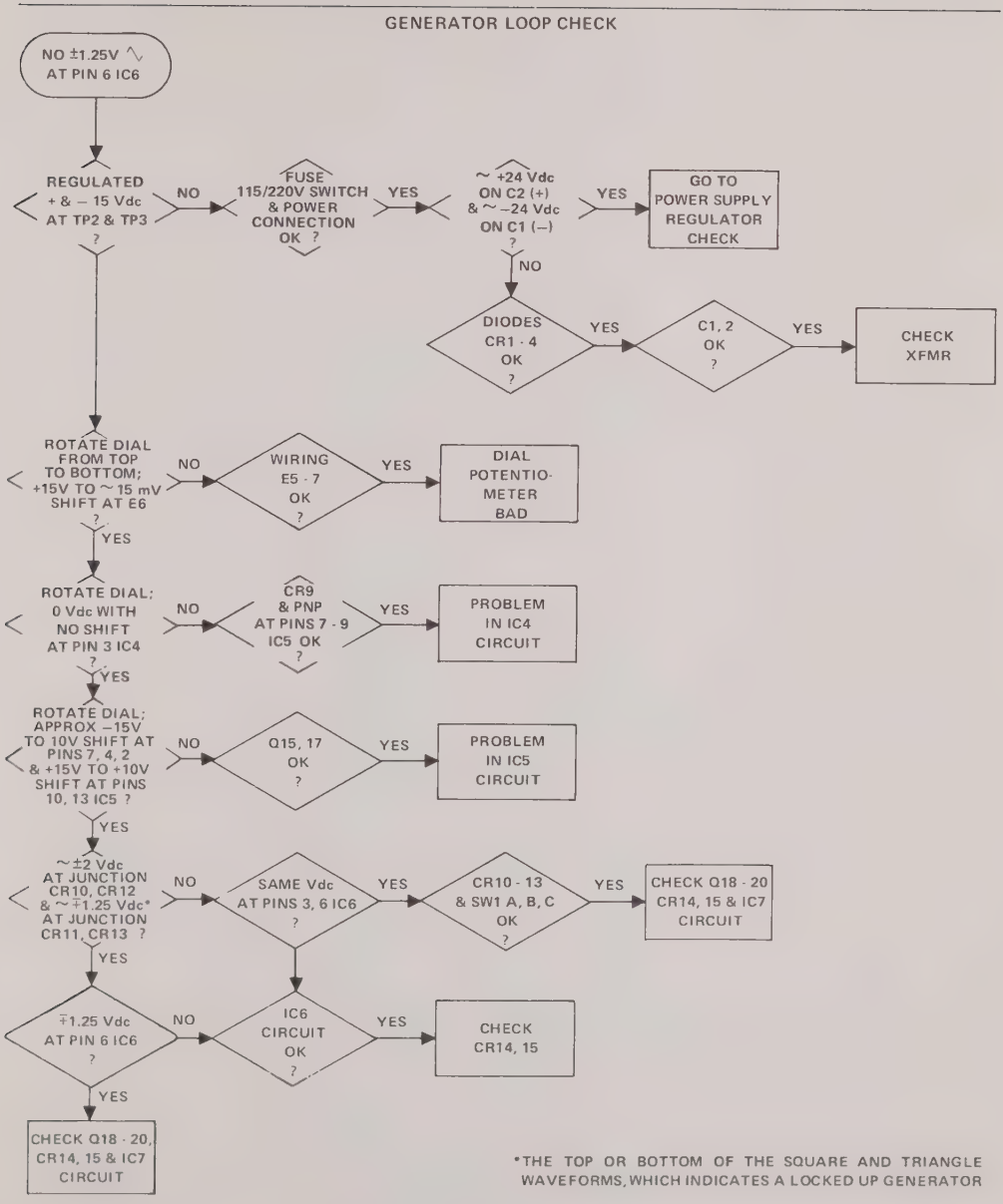
GENERATOR LOOP CHECK
NO ±1.25V ∿ AT PIN 6 IC6
REGULATED + & – 15 Vdc AT TP2 & TP3 ?
NO
FUSE 115/220V SWITCH & POWER CONNECTION OK ?
YES
~ +24 Vdc ON C2 (+) & ~ –24 Vdc ON C1 (–) ?
YES
GO TO POWER SUPPLY REGULATOR CHECK
NO
DIODES CR1 - 4 OK ?
YES
C1, 2 OK ?
YES
CHECK XFMR
ROTATE DIAL FROM TOP TO BOTTOM; +15V TO ~15 mV SHIFT AT E6 ?
NO
WIRING E5 - 7 OK ?
YES
DIAL POTENTIO-METER BAD
YES
ROTATE DIAL; 0 Vdc WITH NO SHIFT AT PIN 3 IC4 ?
NO
CR9 & PNP AT PINS 7 - 9 IC5 OK ?
YES
PROBLEM IN IC4 CIRCUIT
YES
ROTATE DIAL; APPROX –15V TO 10V SHIFT AT PINS 7, 4, 2 & +15V TO +10V SHIFT AT PINS 10, 13 IC5 ?
NO
Q15, 17 OK ?
YES
PROBLEM IN IC5 CIRCUIT
YES
~ ±2 Vdc AT JUNCTION CR10, CR12 & ~ ∓1.25 Vdc* AT JUNCTION CR11, CR13 ?
NO
SAME Vdc AT PINS 3, 6 IC6 ?
YES
CR10 - 13 & SW1 A, B, C OK ?
YES
CHECK Q18 - 20 CR14, 15 & IC7 CIRCUIT
YES
∓1.25 Vdc AT PIN 6 IC6 ?
NO
IC6 CIRCUIT OK ?
YES
CHECK CR14, 15
YES
CHECK Q18 - 20, CR14, 15 & IC7 CIRCUIT
*THE TOP OR BOTTOM OF THE SQUARE AND TRIANGLE WAVEFORMS, WHICH INDICATES A LOCKED UP GENERATOR

Figure 6-1. Troubleshooting Chart (Sheet 2 of 4)

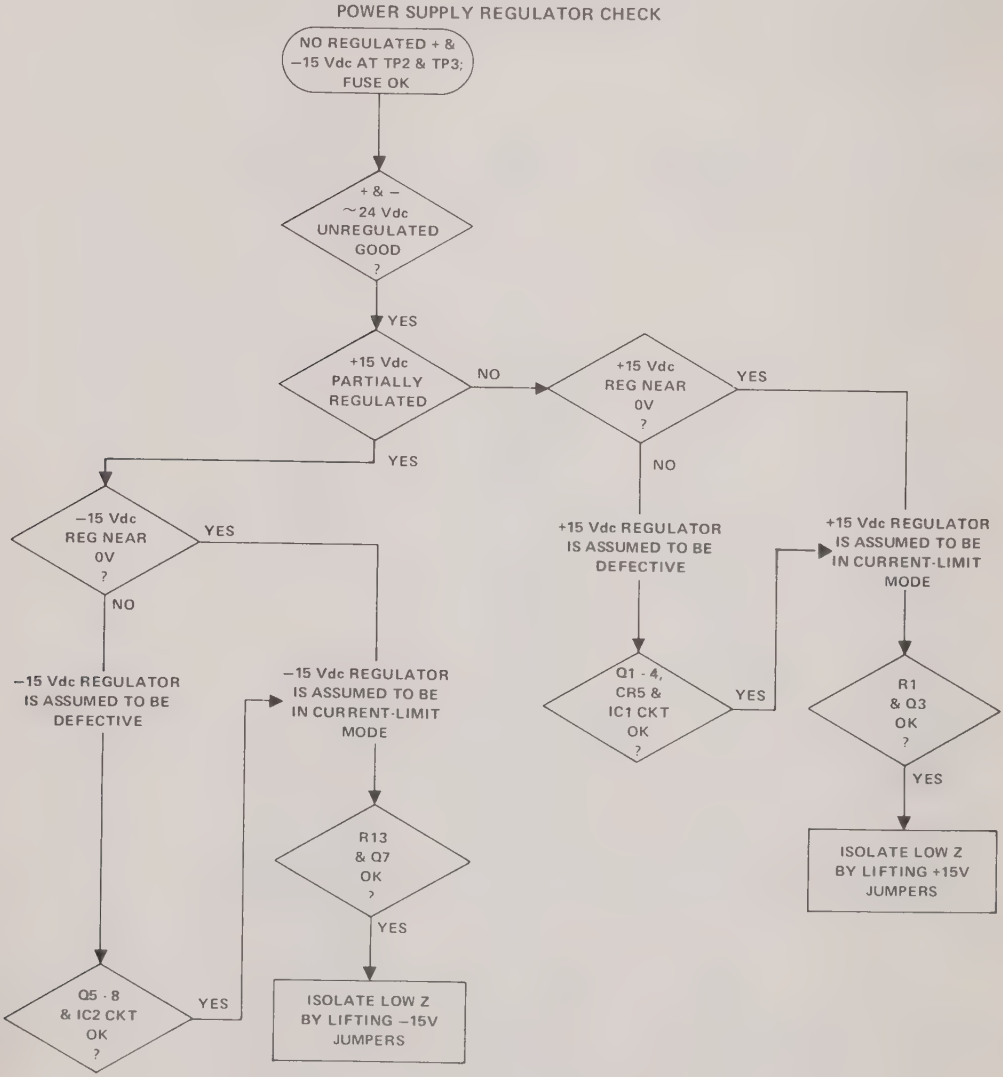
POWER SUPPLY REGULATOR CHECK
NO REGULATED + & −15 Vdc AT TP2 & TP3; FUSE OK
+ & − ~24 Vdc UNREGULATED GOOD ?
YES
+15 Vdc PARTIALLY REGULATED
NO
+15 Vdc REG NEAR 0V ?
YES
YES
NO
−15 Vdc REG NEAR 0V ?
YES
NO
+15 Vdc REGULATOR IS ASSUMED TO BE DEFECTIVE
+15 Vdc REGULATOR IS ASSUMED TO BE IN CURRENT-LIMIT MODE
−15 Vdc REGULATOR IS ASSUMED TO BE DEFECTIVE
−15 Vdc REGULATOR IS ASSUMED TO BE IN CURRENT-LIMIT MODE
Q1 - 4, CR5 & IC1 CKT OK ?
YES
R1 & Q3 OK ?
YES
ISOLATE LOW Z BY LIFTING +15V JUMPERS
R13 & Q7 OK ?
YES
ISOLATE LOW Z BY LIFTING −15V JUMPERS
Q5 - 8 & IC2 CKT OK ?
YES

Figure 6-1. Troubleshooting Chart (Sheet 3 of 4)

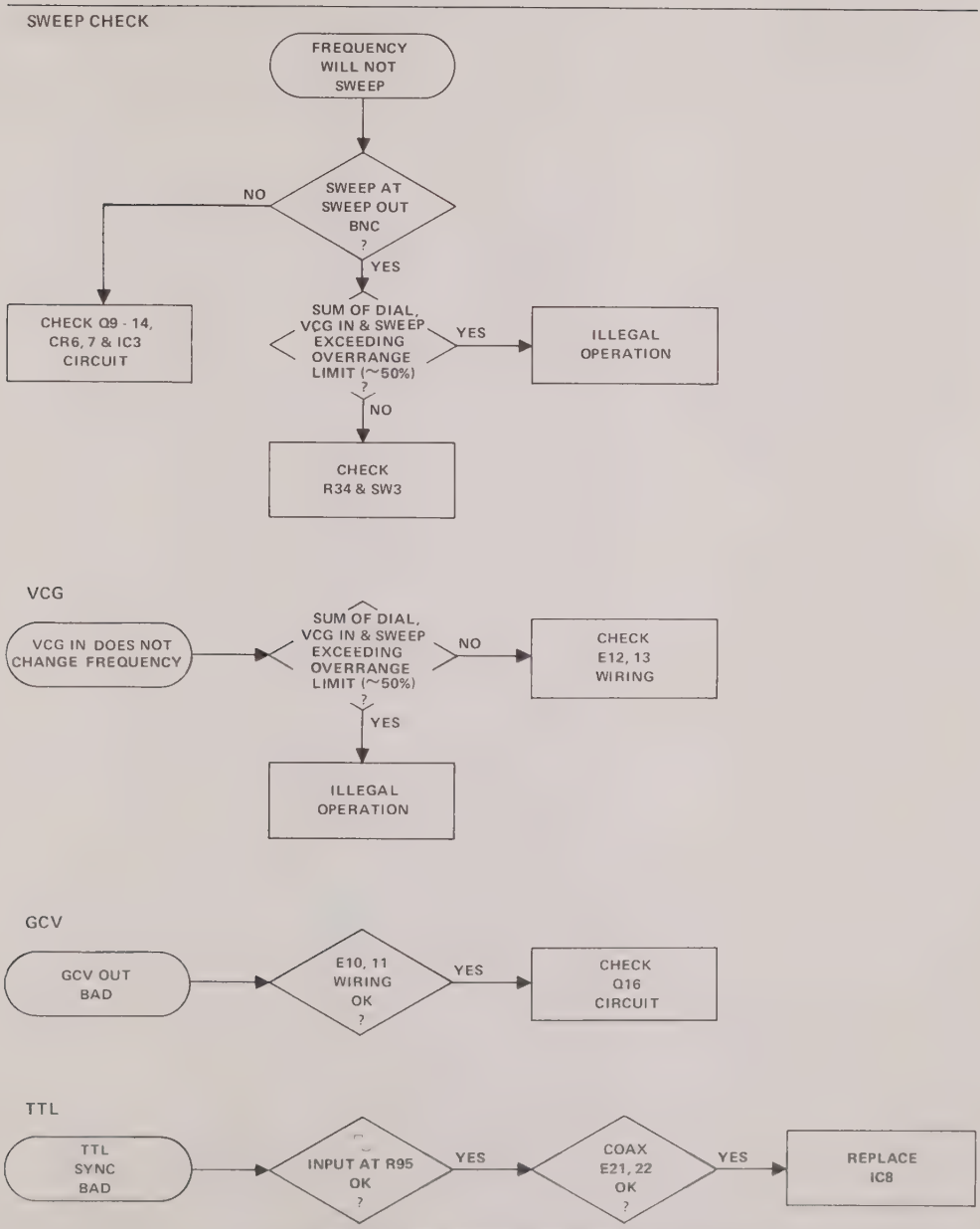

Figure 6-1. Troubleshooting Chart (Sheet 4 of 4)

SECTION 7
PARTS AND SCHEMATICS

7.1 DRAWINGS

The following assembly drawings (with parts lists) and schematics are in the arrangement shown below.

7.2 ORDERING PARTS

When ordering spare parts, please specify part number, circuit reference, board, serial number of unit, and if applicable, the function performed.

7.3 ADDENDA

Under Wavetek's product improvement program, the latest electronic designs and circuits are incorporated into each Wavetek instrument as quickly as development and testing permit. Because of the time needed to compose and print instruction manuals, it is not always possible to include the most recent changes in the initial printing. Whenever this occurs, addendum pages are prepared to summarize the changes made and are inserted immediately inside the rear cover. If no such pages exist, the manual is correct as printed.

	Page No.
CHASSIS	
Schematic	7-2
Assembly Drawing	7-3
Parts List	7-5
MAIN BOARD	
Schematic	7-6
Assembly Drawing	7-7
Parts List	7-8

NOTE

Wavetek considers the XCG board a factory repairable only item; therefore, XCG schematic, drawing and parts list are not included in this manual.

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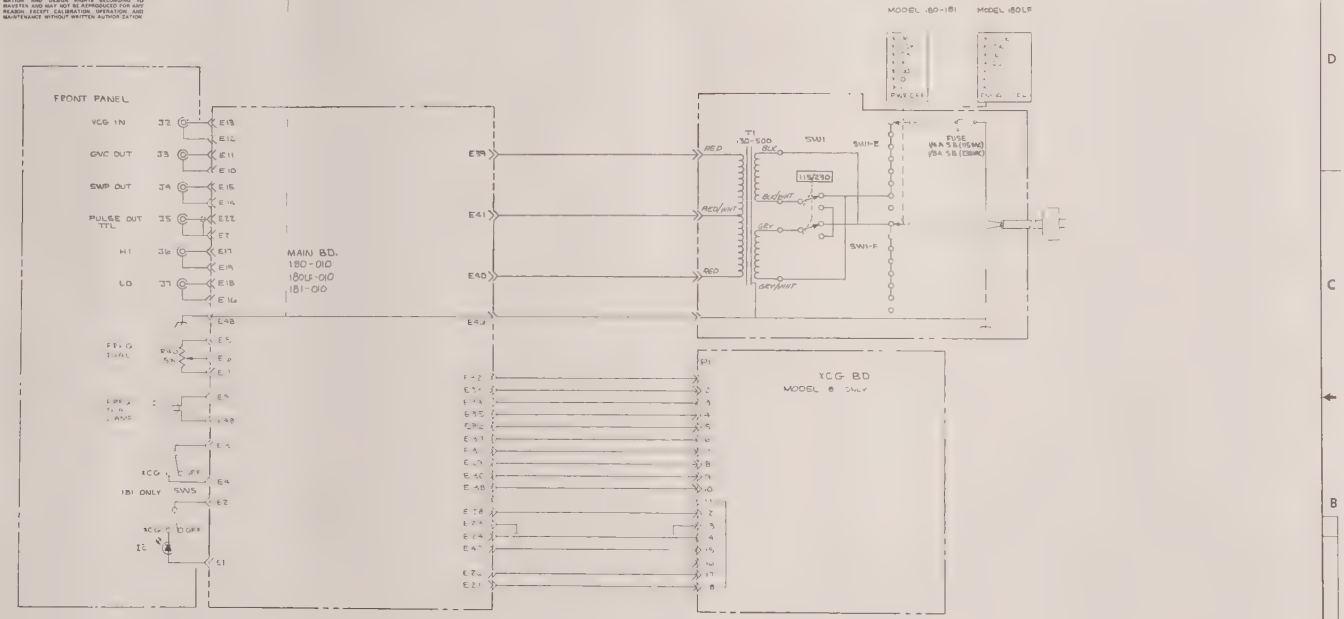

NOTE: UNLESS OTHERWISE SPECIFIED

REMOVE ALL BURRS AND BREAK SHARP EDGES	DRAWN WA	WAVETEK	
MATERIAL	MECHANICAL	TITLE	SCHEMATIC CHASSIS
FINISH WAVETEK PROCESS	DIMENSIONS ARE SPECIFIED IN INCHES. TOLERANCES: .XX ± .010 .XXX ± .005 ANGLES ± 1°		
	DO NOT SCALE DWG	MODEL NO	180-181-180LP
	SCALE	DWG NO	9005-020-0000
		SIZE	23338
		SHEET 1 OF 1	

7-2

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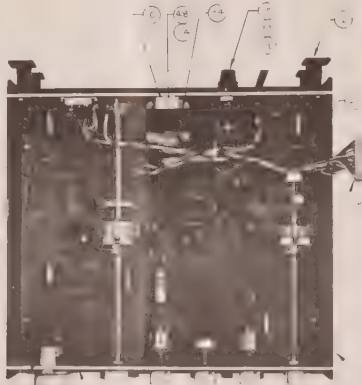


TIP NOT SHOWN

DETAIL B

(4) (25) (33) (81 ONLY)

SEE DETAIL C

DETAIL C

WAVETEK

7-3

ITEM NO	REF DESIG	DESCRIPTION	MFGR PART NO	MFGR	WAVETEK PART/STOCK NO	QTY	STATION NO	PREP NO
1		SCHEMATIC CHASSIS	180-200	WVTK	0005-00-0066			
2		SPACER 8-80	8-80	WVTK	1400-00-0653			
3		DIAL INDICATED	180-303	WVTK	1400-00-4970			
4		CHASSIS ASSEMBLY	180-000	WVTK	0004-00-0066			
5		CHASSIS TOP	180-300-1	WVTK	1400-00-5000	1		
6		POST	180-302	WVTK	1400-00-5020	4		
7		CHASSIS BOTTOM	180-300-2	WVTK	1400-00-5030	1		
8	181	FRONT PANEL	180-310	WVTK	1400-00-5090	1		
9		REAR PANEL	180-306	WVTK	1400-00-5073	1		
10		TRANSFORMER BLOCKS	180-309	WVTK	1400-00-5083	2		
11	J2- 7	BNC's	KC7946	KEN	2100-01-0002	6		
12								
13		SOLDER LUG	1497	SMITH	2100-04-0012	6		
14		DIAL ASSY		WVTK	1400-00-5358	1		
15		KNOB	R867-1-5B-M	B MACK	2400-01-0008	4		
16		KNOB SET	R867-1-5B+D-M-9	B MACK	2400-01-0009	1		
17		LAMP	328-46	MOLE	2600-02-0013	1		
18		FUSE 230V	313-125	LITT F	2400-05-0001	1		
19		FUSE 115V	313-250	LITT F	2400-05-0008	1		
20		FUSE HOLDER	345001	LITT F	2400-05-0012	1		
21		CABLE TIES	TYB-23M-6	T+B/PANC	2800-00-0006	7		
22		STRAIN RELIEF	SR3F-4	HEY	2800-00-0015	1		
23		NYLINERS		EMI	2800-01-0002	5		
24		STANDOFFS (MALE-FEMALE)	1443-MF3-PP5-4-40	KEYS	2800-02-0009	4		
25		BAIL KIT	180-500	WVTK	2800-08-0010	1		
26		FASTENER (FEET)	C7494-632-4	TINN	2800-09-0003	6		
27		CHASSIS BLOCKS	1591C-11	HAM	2800-09-0022	2		
28		SHOULDER WASHER	2668	KEYS	- - 0006	22		
29		LED/WITH HARDWARE	711-220	MV	4899-00-0006	1		
30		SWITCH	7291 PDCN	CH	5104-00-0009	1		
31		SWITCH 115/230 (SOLDER SHIELD)	SW-22/SC	CH	5105-00-0001	1		
32								
33		TRANSFORMER	130-500	WVTK	5600-00-0005			
34		SHRINK TUBING	FIT-221-1/8	RAY	6001-20-2000	AR		
35		SHRINK TUBING	FIT-221-3/16	RAY	6001-20-3000	AR		
36		SHRINK TUBING	FIT-301-1/2	RAY	6001-20-8000	AR		
37		POWER CORD	17237	BELDEN	6001-80-0001	1		
38		POP RIVETS	4 X 641	DAYTON				

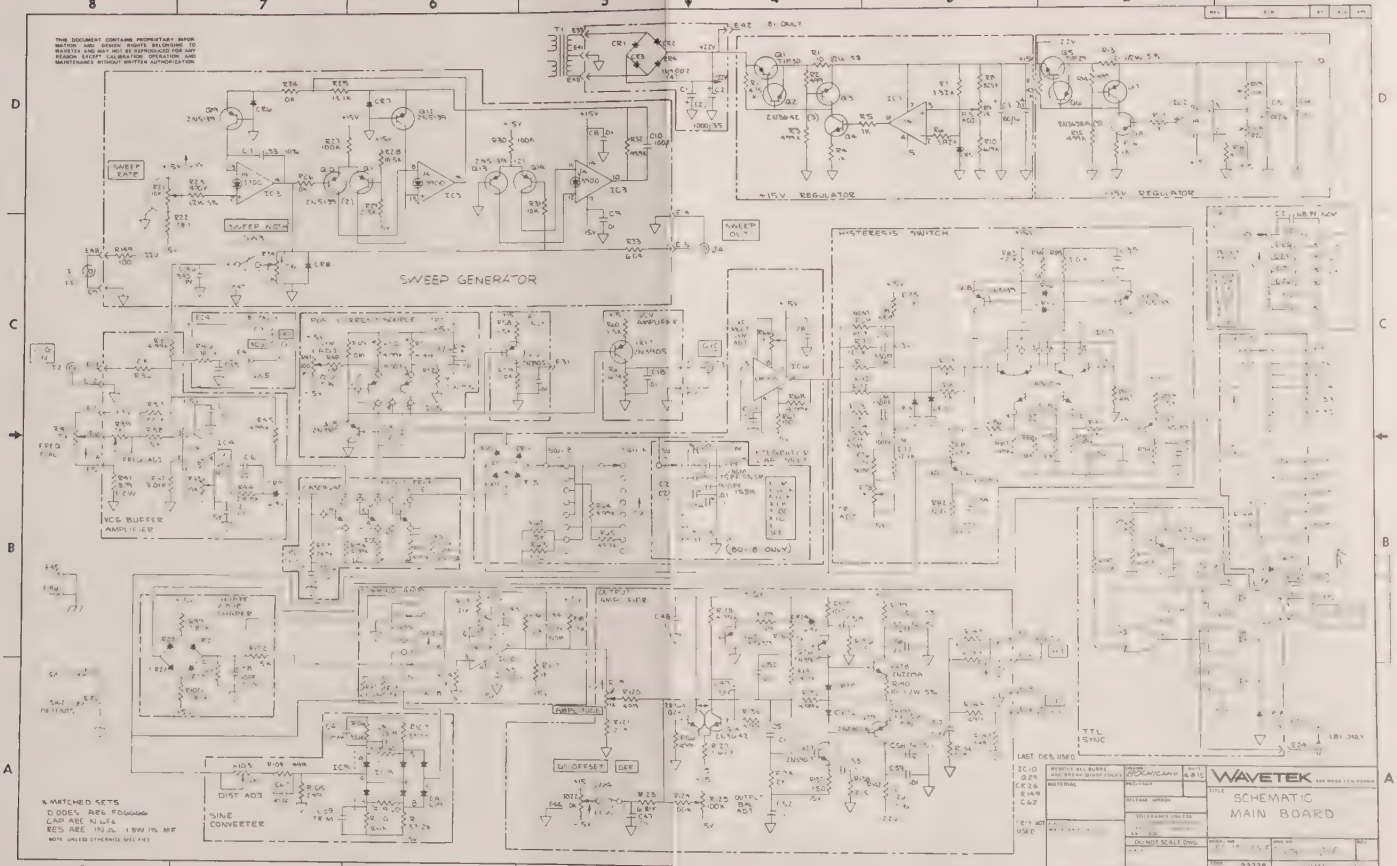
WAVETEK® PARTS LIST	TITLE CHASSIS ASSEMBLY	DRAWN BY [illegible]	NO 1704-00-0068	REV
	MODEL 181	[illegible]	181-000	
			SH 1 OF 2	

Form 102

ITEM NO	REF DESIG	DESCRIPTION	MFGR PART NO	MFGR	WAVETEK PART/STOCK NO	QTY	STATION NO	PREP NO
39		POWER WAFER	130-SW1-3	WVTK	5104-00-0007			
40								
41		THERMAL COMPOUND	120-2	[illegible]				
42		NUT #4						
43		LOCK WASHER #4						
44		[illegible]						
45		[illegible]						
46		[illegible]						
47		[illegible]						
48		[illegible]						
49		[illegible]						
50		[illegible]						
51		[illegible] WASHER #8						
52		[illegible] #2 X 3/4						
53		[illegible] #2 X 5/8 SELF TAPING						
54		[illegible] #2 X 2-1/4 BLK OXIDE						
55		WIRE BLACK			6000-32-2001			
56		WIRE GREEN			6000-32-2005			
57		WIRE BLUE			6000-32-2006			
58		WIRE VIOLET			6000-32-2007			
59		WIRE WHITE			6000-32-2009			
60		WIRE BLACK/WHITE			6000-32-2090			
61		WIRE RED/WHITE			6000-32-2092			
62		WIRE ORANGE/WHITE			6000-32-2093			
63		WIRE YELLOW/WHITE			6000-32-2094			
64		WIRE GREEN/WHITE			[illegible]			
65		WIRE BLUE/WHITE			6000-32-2096			
66		WIRE VIOLET/WHITE			6000-32-2097			
67		WIRE GRAY/WHITE			[illegible]			
68		[illegible]	94741V		[illegible]			
69		POWER CORD HOLDER		WVTK	1400-00-5400	1		
70		SERIAL TAG	180-318	WVTK	1400-00-5390	1		
71		MAIN PC ASSY	181-010	WVTK	1700-00-0180	1		
72		WAVETEK LOGO	139-305	WVTK	1400-00-2180	1		
73								
74		SOLDER LUG	1414-4	SMITH	2100-04-0004			

WAVETEK® PARTS LIST	TITLE CHASSIS ASSEMBLY	DRAWN BY [illegible]	NO 1704-00-0068	REV
	MODEL 181	[illegible]	181-000	
			SH 2 OF 2	

Form 102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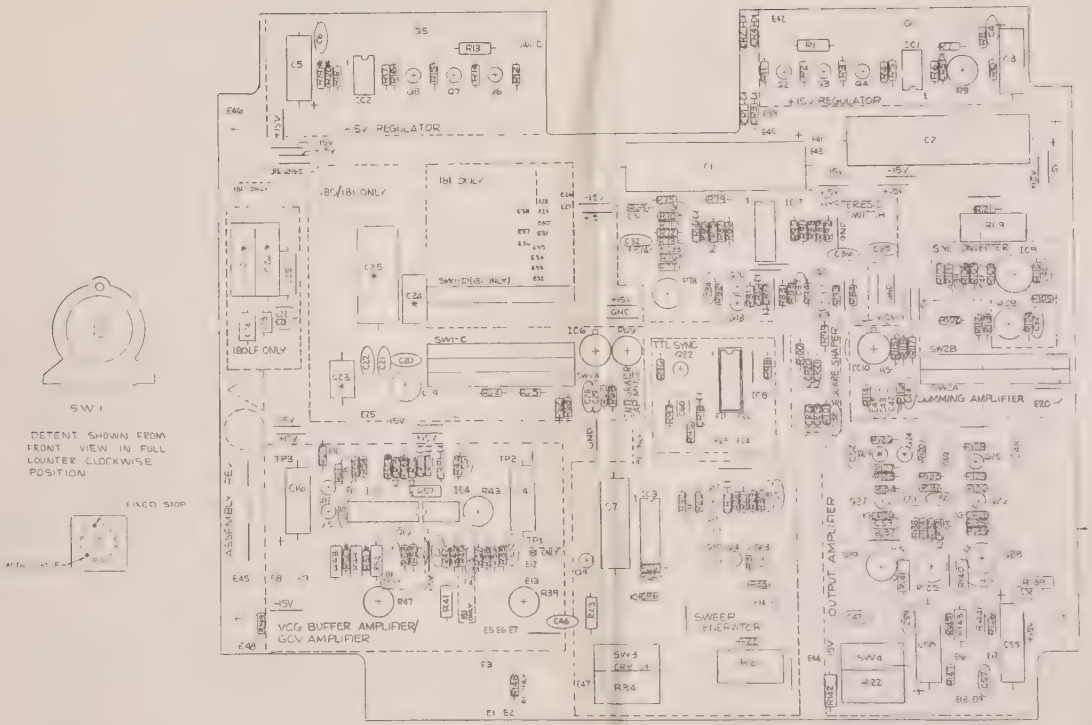
SWEEP GENERATOR
HYSTERESIS SWITCH
+15V REGULATOR
-15V REGULATOR
VCG BUFFER AMPLIFIER
SINE CONVERTER
TTL SYNC
WAVETEK
SCHEMATIC
MAIN BOARD
23338
LAST DES USED
7-6



DRAWN	DATE	WAVETEK
PROTOTYPE		TITLE: SILKSCREEN ASSEMBLY PRINT
RELEASE APPROVAL		
TOLERANCE UNLESS OTHERWISE SPECIFIED .XX ±0.02 ANGLES ±1°		
DO NOT SCALE DWG	MODEL NO. 180 181 181A	DWG NO. 0001-010-0 18 REV
SCALE 1/1	SIZE C	SHEET OF 1

ITEM NO	REF DESIG	DESCRIPTION	MFGR PART NO.	MFGR	WAVETEK PART/STOCK NO.	QTY	STATION NO	PREP NO
1		SILKSCREEN ASSY PRINT	180-010	WVTK	0001-00-0178			
2		PRINTED CIRCUIT BOARD	180-110	WVTK	1703-00-0178	1		
3		SCHEMATIC	180-210	WVTK	0002-00-0178			
4								
5								
6								
7		CAPACITORS						
8	C38, C44	CERAMIC DISC 1000V, 10PF	DD100	CRL		2	3-50, 5-5	C4
9	C49	CERAMIC DISC 1000V, 15PF	DD150	CRL		1	5-9	
10	C62	CERAMIC DISC 1000V, 82PF	DD820	CRL		1	2-50	
11	C10	CERAMIC DISC 1000V, 100PF	DD101	CRL		1	4-38	
12	C39, C57	CERAMIC DISC 1000V, 220PF	DD221	CRL		2	2-43, 5-48	
13	C41, C46	CERAMIC DISC 1000V, 330PF	DD331	CRL		2	2-38, 4-28	
14	C15, C61	CERAMIC DISC 1000V, .001uF	DD102	CRL		2	3-14, 4-1	
15	C4,C6,C8	CERAMIC DISC [illegible]	DD103	CRL		[illegible]	[illegible]	
	C9, [illegible]							
	C45,[illegible]							
	C47,C50,C51							
	C54,C59,C13						5-21,5-22,5-40	
	C17						5-41, 5-50, 4-15	
16	C35, [illegible]	CERAMIC DISC [illegible]	[illegible]	CRL		[illegible]	[illegible]	
	C43,C44,						3-47, 3-48, 5-6	
	C53,C54, C36						5-11,5-25,5-31	
17								
18								
19	C37	SILVER MICA 5% 330PF	DM15-331J	SAGMO		1	3-[illegible]	
20	C23	SILVER MICA 5% 390PF	DM15-391J	SAGMO		1	3-[illegible]	
21	C31,C32	SILVER MICA 5% 330PF	DM15-331J	SAGMO		2	1-43, 1-48	C4
22	C22	SILVER MICA 1% 910PF	DM15-911F	SAGMO		2	1-39, 1-40	C4
23						2	1-34	C4
24	C19	VARIABLE [illegible]	[illegible]	MFRDP		1	[illegible]	
25								
26	C7	MYLAR 100V, .33uF	MMF-1P33	CDE		1	B1.3, C8	
27	C55, C58	ELECTROLYTIC 50V, 50uF	500D506G050DD7	SPRAG		2	DIE, 1830	
28	C3,C5,C14,C16	ELECTROLYTIC 16V, 100uF	500D107G016DC7	SPRAG		4	B1, C8	
29	C1,C2	ELECTROLYTIC 35V, 1000uF	30D10G035CC4	SPRAG		2	B1, C8	

WAVETEK PARTS LIST

TITLE P/C MAIN BOARD
MODEL 181
DRAWN BY
APPROVAL
NO. 1700-00-0180
181-010
REV
SH 1 OF 6

Form 102

ITEM NO	REF DESIG	DESCRIPTION	MFGR PART NO	MFGR	WAVETEK PART/STOCK NO.	QTY	STATION NO	PREP NO
31								
32		CAPACITOR SET						
33	C23	METAL POLYCARBON 100V, .01uF	180-501-101	WVTK		1 set	Bag and ID	
34	C24	METAL POLYCARBON 100V, .1uF						
35	C25	METAL POLYCARBON 100V, 1uF						
36								
37								
38								
39	CR1, CR2	DIODE 1N4002	1N4002	SMTH	4801-02-0001	6	1-13, 1-14, 1-15	
40	CR3, CR4						1-16, 1-17	
41	CR5,CR9,CR26	DIODE, ZENER 1N4581	1N4581	MICRO	4801-01-4581	3	1-29, 3-12, 5-34	
42	CR6, CR7,CR8	FD6666	FD6666	FCHLD	4807-02-6666	14	2-2, 2-4, 2-13	
	CR14,CR15,CR16						2-14, 3-30, 3-36	
	CR17,CR18,CR20						3-37, 3-38, 3-39	
	CR21,CR22,CR23						4-35, 4-36, 4-42	
	CR25, CR26						5-24, 5-32	
43	CR10,CR11	DIODE FD7777	FD7777	FCHLD	4807-02-0777	4	3-8, 3-9, 3-10	
	CR12,CR13						3-11	
44								
45		INTEGRATED CIRCUITS						
46	IC1,IC2,IC4	OPERATION AMPLIFIER UA741		NAT	7000-07-4100	3	1-3, 1-26, 4-5	
47	IC6	180-501-103		WVTK		1	3-17	
48	IC10	LM-318		NAT	7000-03-1800	1	3-14	
49	IC9	QUAD DIODE ARRAY + 2 DIODES CA3019		RCA	7000-30-1900	1	2-40/41	
50	IC7	CA3054		FCHLD	7000-30-5400	1	2-15/16	
51	IC5	CA3096AE		FCHLD		1	4-3/4	
52	IC3	LM3900		FCHLD	7000-39-0000	1	4-30/31	
53	IC8	QUAD 2 INPUT NAND GATE 7400		FCHLD	8000-74-0000	1		
54								
55								
56		TRANSISTOR						
57	Q5	WITH MTG KIT-TIP 29	TIP 29	T.I.	4902-00-0290	1		
58	Q1	WITH MTG KIT-TIP 30	TIP 30	T.I.	4902-00-0300	1		
59	Q28	2N2218A	2N2218A	NOT	4901-02-2181	1	5-39	
60	Q29	2N2905A	2N2905A	FCHLD	4901-02-9050	1	5-35	
61	Q6,Q7,Q8	MPS3638A	MPS3638A	FCHLD		3	1-6, 1-8, 1-11	

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61	Q2, [illegible]	TRANSISTOR [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	Q22						
62	Q27		2N3903	2N3903	FCHLD	4901-03-9030	1
63	Q13,Q17,Q26		2N3905	2N3905	FCHLD	4901-03-9050	4
	Q36						
64	Q9,Q10,Q11		2N5139	2N5139	FCHLD	4901-05-1390	11
	Q12,Q13,Q14						
	Q18,Q19,Q20						
	Q21,Q25						
65							
66		MATCHED TRANSISTOR					
67	Q23,Q24		2N3642	180-501-102	WVTK	4998-00-0011	1 set Bag 6 ID
68							
69		RESISTORS					
70	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
71	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
72	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]						
73	R121,R122,	METAL FILM [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	R166						
74	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
75	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	[illegible]						3-47, 3-48, 5-6
	[illegible]						5-11,5-25,5-31
76	R67,R82,R9-	METAL FILM 1/8W, 1%, 100	RN55D1000F	CRMC	4701-03-1000	5	
	R135, R149						
77	R143, R144	METAL FILM 1/2W, 1%, 100	RN60D1000F	CRMC	4701-13-1000	2	
78	R137	METAL FILM 1/8W, 1%, 150	RN55D1500F	CRMC	4701-03-1500	1	
79	R100, R100	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
80	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
81	R2,R14,R92	METAL FILM [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	R104,R120,R126						
	R133,R145						
82	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
83	R59,R60,	METAL FILM [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	R59						
84	R4,R5,R16	METAL FILM [illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
	R17,R71,R72						
	R79, R80, R86						
	R90, R[illegible]						

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85	R46	METAL FILM 1/8W, 1%, 78.7K	RN55D7872F	CRMC	4701-03-7872	[illegible]	[illegible]
86	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
87	R95,R115,R116	METAL FILM 1/8W, 1%, 1.21K	RN55D1211F	CRMC	4701-03-1121	[illegible]	[illegible]
88	R60,R81,R84	METAL FILM 1/8W, 1%, 1.5K	RN55D1501F	CRMC	4701-03-1501	[illegible]	[illegible]
	R93,R102,R113						
	R119,R58,R148						
89	R89,R101	METAL FILM 1/8W, 1%, 1.78K	RN55D1781F	CRMC	4701-03-1781	[illegible]	[illegible]
90	R56,R130,R134	METAL FILM 1/8W, 1%, 2K	RN55D2001F	CRMC	4701-03-2001	[illegible]	[illegible]
91	R90	METAL FILM 1/8W, 1%, 2.21K	RN55D2211F	CRMC	4701-03-2001	[illegible]	[illegible]
92	R87,R98	METAL FILM 1/8W, 1%, 2.49K	RN55D2491F	CRMC	4701-03-2491	[illegible]	[illegible]
93	R62,R83,R85	METAL FILM 1/8W, 1%, 3.01K	RN55D3011F	CRMC	4701-03-3011	[illegible]	[illegible]
94	R7	METAL FILM 1/8W, 1%, 3.32K	RN55D3321F	CRMC	4701-03-3321	[illegible]	[illegible]
95	[illegible]	METAL FILM 1/8W, 1%, 3.65K	RN55D3651F	CRMC	4701-03-3651	[illegible]	[illegible]
96	[illegible]	METAL FILM 1/8W, 1%, 3.92K	RN55D3921F	CRMC	4701-03-3921	[illegible]	[illegible]
97	R11,R12,R18	METAL FILM 1/8W, 1%, 4.75K	RN55D4751F	CRMC	4701-03-4751	[illegible]	[illegible]
98	R3,R15,R35	METAL FILM 1/8W, 1%, 4.99K	RN55D4991F	CRMC	4701-03-4991	[illegible]	[illegible]
	R45,R54,R64						
99	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
100	R97,R123	METAL FILM 1/8W, 1%, 6.19K	RN55D6191F	CRMC	4701-03-6191	[illegible]	[illegible]
101	R99,R100	METAL FILM 1/8W, 1%, 6.81K	RN55D6811F	CRMC	4701-03-6811	[illegible]	[illegible]
102	R8	METAL FILM 1/8W, 1%, 7.87K	RN55D7871F	CRMC	4701-03-7871	[illegible]	[illegible]
103	R24,R26,R31	METAL FILM 1/8W, 1%, 8.25K	RN55D8251F	CRMC	4701-03-8251	[illegible]	[illegible]
104	R88,R96	METAL FILM 1/8W, 1%, 10K	RN55D1002F	CRMC	4701-03-1002	[illegible]	[illegible]
105	R28	METAL FILM 1/8W, 1%, 10.5K	RN55D1052F	CRMC		[illegible]	4-34, 5-1
106	R70,R73,R75	METAL FILM 1/8W, 1%, 12.1K	RN55D1212F	CRMC	4701-03-1052	1	4-42
	R77,R112				4701-03-1217	5	1-44, 1-47, 1-48
107	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	2-46
108	R38, R62	METAL FILM 1/8W, 1%, 15K	RN55D1312F	CRMC	4701-03-1312	1	4-39
109	R29	METAL FILM 1/8W, 1%, 21.5K	RN55D1502F	CRMC	4701-03-1502	2	2-19, 4-23
110	R44,R53,R131	METAL FILM 1/8W, 1%, 24.9K	RN55D2152F	CRMC	4701-03-2152	1	4-44
111	R106,R110	METAL FILM 1/8W, 1%, 30.1K	RN55D2492F	CRMC	4701-03-2492	3	3-6, 3-13, 5-17
112	R107,R111	METAL FILM 1/8W, 1%, 33K	RN55D3012F	CRMC	4701-03-3012	2	2-36, 2-42
113	R32,R65	METAL FILM 1/8W, 1%, 33.2K	RN55D3322F	CRMC	4701-03-3322	2	2-33, 2-34
114	R27,R30,R124	METAL FILM 1/8W, 1%, 49.9K	RN55D4992F	CRMC	4701-03-4992	2	3-16, 4-37
115	R37	METAL FILM 1/8W, 1%, 100K	RN55D1003F	CRMC	4701-03-1003	3	4-43, 4-45, 5-28
116	R76	METAL FILM 1/8W, 1%, 221K	RN55D2213F	CRMC	4701-03-2213	1	4-22
117	R[illegible]	METAL FILM 1/8W, 1%, 237K	RN55D2373F	CRMC	4701-03-2373	1	1-49
118	[illegible]	CARBON 1/2W, 10%, 470K	RCD0C/6474K	STKPL	4700-25-4703	2	4-2, 4-32

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117	R48,R52	CARBON 1/2W, 5%, 1M	RC20GF105J	STKPL	4700-25-1004	2	4-8, 4-10	.5
118	R49	CARBON 1/2W, 5%, 10M	RC20GF106J	STKPL	4700-25-1005	1	4-9	.5
119		MATCHED RESISTORS						
120	R50,R51,R55,R56	METAL FILM 1/8W, 1%, 4.99K	180-501-100	WVTK	4789-00-0039	1 set	Bag & ID	.4
121	R19,R20	METAL FILM 1/8W, 1%, 10K	142-501-64A	WVTK	4789-00-0019	1 set	Bag & ID	.4
122	R103	POTENTIOMETERS 200	91AR-200	BECK	4600-12-2010	1	2-48	C8
123	R9,R66,R78	1K	91AR-1K	BECK	4600-12-1020	3	1-30, 2-7, 3-18	C8
124	R39	2K	91AR-2K	BECK	4600-12-2020	1	4-27	C8
125	R43	10K	91AR-10K	BECK	4600-12-1030	1	4-6	C8
126	R47,R125	100K	91AR-100K	BECK	4600-12-1040	2	4-11, 5-37	C8
127								
128								
129								
130		TRANSIPADS	10160	ROSS	2800-11-0004	2		
131		HEATSINK	NF207	WKFLD	2800-11-0001	3		
132		14 PIN DIP SOCKET	14 DIP	ROBNUG	2100-03-0011	1	3-31/32	
133		SWITCH DETENT (180-400)	180-313	WVTK	5104-99-0022	1		
134		SWITCH DETENT (180-400)	180-314	WVTK	5104-99-0023	1		
135		WAFER	147-400	WVTK	5104-02-0015	6		
136	R21	POT	JK1303	CTS	4600-06-1039	1		
137	R34,R122	POT/SWITCH (GH1879)	180-3	WVTK		2		
138		SOLDER LUG	1497	SMITH	2100-04-0012	2		
139	R119	POT AMPLITUDE	180-401	WVTK	4600-06-1023	1		
140								
141								
142		CONNECTOR BLOCK	09-60-1091	MOLEX	2100-02-0052	2		
143		CONNECTOR PINS	08-05-0106	MOLEX	2100-05-0025	17		
144								
145		WIRE						
146		22GA BLACK			6000-32-2000			
147		BROWN			6000-32-2001			
148		RED			6000-32-2002			
149		ORANGE			6000-32-2003			
150		YELLOW			6000-32-2004			
151		GREEN			6000-32-2005			
152		BLUE			6000-32-2006			
153		VIOLET			6000-32-2007			
154		GREY			6000-32-2008			

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155		WHITE			6000-32-2009			
156		BLACK/WHITE			6000-32-2090			
157		BROWN/WHITE			6000-32-2091			
158		RED/WHITE			6000-32-2092			
159		ORANGE/WHITE			6000-32-2093			
160		GREEN/WHITE			6000-32-2095			
161		VIOLET/WHITE			6000-32-2097			
162		GREY/WHITE			6000-32-2098			
163								
164		COAX	RG 174/U		6001-40-0001			

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